Due Oct 25th 9am
(Review exercises at pre-req
level from a past exam.)

EE5200
T-LINE EXER.

1) [10pts] A stranded all-aluminum conductor has a dc resistance of 0.02 Ω per 1000 ft at 20°C, and an ac resistance of 0.14 Ω per mile at 50°C.

   a) Calculate the dc resistance at 50°C.
   b) What is the per cent increase in resistance caused by skin effect?

2) [10pts] Calculate the D_{sc} and D_{eq} that would be used for capacitance calculations. The radius of all conductors is ½".
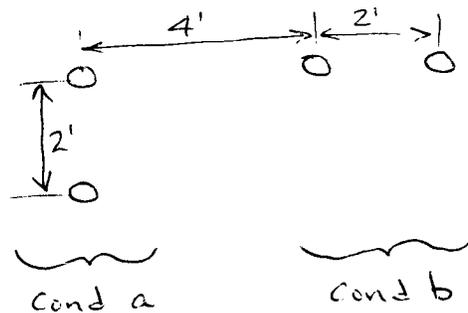
3) [5pts] Explain how the GMR is determined in the case of a stranded conductor.

4) [20pts] A single phase transmission line is composed of a phase conductor and return conductor that each are 26/7 ACSR Squab. The two conductors are spaced 5 ft apart.

    a) What radius value should be used for inductance calculations?
    b) What radius value should be used for capacitance calculations?
    c) Calculate the total inductance of the line in H/m.
    d) Calculate the capacitance between conductors and the capacitance to neutral in F/m.

5) [5 pts] Explain the difference between the capacitance to neutral and the capacitance between conductors. Thinking question: What would you expect to happen to the capacitance to neutral if the height of the line is increased?

6) [20 pts] A standard single-tower design is used for a 69-kV single circuit transmission line, as shown. Each phase consists of 3 conductors of 6/1 ACSR Partridge, with a 4" bundle spacing. Neglecting the line's proximity to earth, assuming continuous transposition, and assuming that no current returns through the earth,

   a) Calculate the 60-Hz resistance at 50°C in Ω/km per phase (assume that $R_{AC} = R_{DC}$ at 25°C).
   b) Calculate the GMR and GMD used to calculate inductance for this conductor arrangement.
   c) Calculate the GMR and GMD used to calculate capacitance for this conductor arrangement.
   d) Calculate inductive reactance in Ω/km and capacitive susceptance in $\mho$/km per phase.
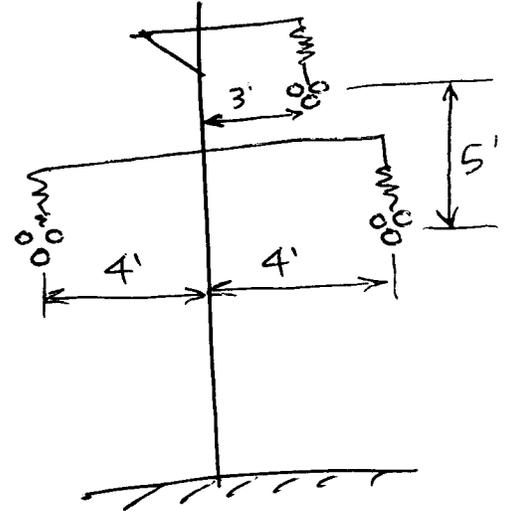
7) [5 pts] Short Essay: In terms of increasing or decreasing inductance, what effect do each of the following have?

   - Decreasing height above ground.
   - Using a smaller conductor.
   - Decreasing the bundle spacing.
   - Increasing the phase spacing.

8) [20 pts] Two tap changing transformers are paralleled. On the 100 MVA system base, the impedances of T1 and T2 are j.05 pu and j.04 pu respectively. T1 is rated 90 MVA and T2 is rated 100 MVA.

   a) With the taps of both transformers in the neutral position, what percent of total load current flows through each transformer?

   b) What is the maximum total per unit load that the paralleled transformers can supply? Calculate the per unit load through each transformer for this case. Which transformer is the limiting factor?

   c) If the tap changers are moved so that the load voltage increases, does the VAR flow through the transformers increase or decrease? Why? Will the power flow change appreciably?
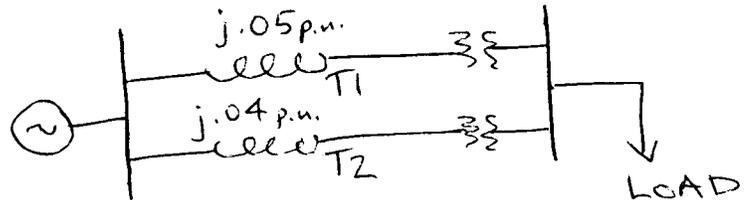
9) [5 pts] What is transposition? What is the advantage in continuously transposing a transmission line? Explain in terms of ease of per phase calculation, using sequence impedances, etc.

EE 484

$\boxed{\text{Equations - Test 3}}$

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

$$L_{INT} = \frac{1}{2} \times 10^{-7} \text{ H/m}$$

$$L_{ToT} = 2 \times 10^{-7} \ln \frac{Deq}{D_{SL}} \text{ H/m} \overset{*}{=} 0.7411 \log_{10} \frac{Deq}{D_{SL}} \text{ mH/mi}$$

$$\left(L_{ToT_{2-WIRE}} = 4 \times 10^{-7} \ln \frac{Deq}{D_{SL}} \text{ H/m} \right)$$

Note: D_{SL} based on r'!

$* \frac{1}{2}$ of single phase loop
or L-N per phase of 3φ ckt.

$$\varepsilon_0 = 8.854 \times 10^{-12} \text{ F/m}$$

$$C_n = \frac{2\pi\varepsilon_0}{\ln \frac{Deq}{D_{SC}}} \text{ F/m} = \frac{0.0388}{\log \frac{DEQ}{D_{SC}}} \text{ μF/mi to neu}$$

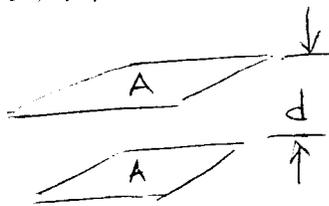Note: D_{SC} based on r.

Earth Proximity:

$$C_n = \frac{0.0388}{\log \frac{Deq}{D_{SC}} - \log \sqrt[3]{\frac{H_{12} H_{23} H_{31}}{H_1 \; H_2 \; H_3}}} \text{ μF/mi to neu}$$

parallel plate capaciter:

$$C = \frac{\varepsilon A}{d}$$

$$R_{T2} = R_{T1} \left(\frac{T_2 + T}{T_1 + T} \right)$$

$T = 241.5°C$ (C)

$T = 225.1°C$ (A)

CONDUCTOR	SIZE (KCM)	AL/STL	AREA (SI)	DIAM (IN)	WEIGHT (LB/FT)	RATED STREN (LBS)	L OHMS /MI	C MOHM /MI	R-25C OHMS /MI	R-50C OHMS /MI	CHART #	GMR (FT)	% WT ALUM
TURKEY	26.2	6/ 1	.0240	.198	.036	1190	.636	.1423	3.4590	3.9400	1-1023	.0053	67.90
SWAN	41.7	6/ 1	.0383	.250	.057	1860	.604	.1353	2.1780	2.5180	1-1023	.0069	67.90
SWANATE	41.7	7/ 1	.0411	.257	.067	2360	.608	.1346	2.1540	2.5230	1-670	.0067	58.10
SPARROW	66.4	6/ 1	.0608	.316	.091	2850	.578	.1284	1.3720	1.6280	1-1023	.0085	67.90
SPARATE	66.4	7/ 1	.0653	.325	.107	3640	.579	.1276	1.3570	1.6350	1-1023	.0085	58.10
GROUSE	80.0	8/ 1	.0847	.370	.149	5200	.570	.1240	1.1200	1.4040	1-430	.0091	50.40
ROBIN	83.8	6/ 1	.0767	.355	.115	3550	.564	.1250	1.0890	1.3050	1-938	.0096	67.90
PETREL	101.8	12/ 7	.1266	.461	.254	10400	.540	.1172	.8510	1.0840	1-546	.0117	37.80
RAVEN	105.7	6/ 1	.0967	.398	.145	4380	.550	.1216	.8640	1.0520	1-938	.0108	67.90
MINORCA	110.8	12/ 7	.1378	.481	.277	11300	.535	.1160	.8010	1.0240	1-546	.0122	37.80
QUAIL	133.2	6/ 1	.1219	.447	.183	5310	.536	.1186	.6860	.8530	1-938	.0121	67.90
LEGHORN	134.6	12/ 7	.1674	.530	.336	13600	.525	.1131	.6460	.8450	1-546	.0132	37.80
GUINEA	159.0	12/ 7	.1977	.576	.397	16000	.516	.1106	.5470	.7310	1-546	.0142	37.80
PIGEON	167.7	6/ 1	.1538	.502	.231	6620	.520	.1147	.5450	.6900	1-938	.0137	67.90
DOTTEREL	176.9	12/ 7	.2200	.607	.441	17300	.509	.1091	.4930	.6670	1-546	.0151	37.80
DORKING	190.8	12/ 7	.2373	.631	.476	18700	.504	.1079	.4570	.6250	1-546	.0157	37.80
BRAHMA	203.2	16/19	.3020	.714	.667	20700	.489	.1043	.4120	.5530	1-546	.0178	28.30
COCHIN	211.3	12/ 7	.2628	.663	.528	28400	.498	.1065	.4130	.5750	1-546	.0165	37.80
PENGUIN	211.6	6/ 1	.1939	.563	.291	8350	.508	.1113	.4340	.5690	1-938	.0152	67.90
WAXWING	266.8	18/ 1	.2211	.609	.289	6880	.476	.1090	.3488	.3831	1-844	.0198	86.45
PARTRIDGE	266.8	26/ 7	.2436	.642	.367	11300	.465	.1074	.3452	.3792	1-782	.0217	68.60
OSTRICH	300.0	26/ 7	.2740	.680	.413	12700	.458	.1057	.3070	.3372	1-782	.0229	68.60
MERLIN	336.4	18/ 1	.2789	.684	.365	8680	.462	.1055	.2767	.3037	1-844	.0222	86.45
LINNET	336.4	26/ 7	.3072	.721	.463	14100	.451	.1040	.2737	.3006	1-782	.0243	68.60
ORIOLE	336.4	30/ 7	.3259	.741	.527	17300	.445	.1032	.2719	.2987	1-773	.0255	60.35
CHICKADEE	397.5	18/ 1	.3295	.743	.432	9940	.452	.1031	.2342	.2572	1-844	.0241	86.45
BRANT	397.5	24/ 7	.3527	.772	.512	14700	.444	.1018	.2367	.2600	1-889	.0259	73.25
IBIS	397.5	26/ 7	.3630	.783	.547	16300	.441	.1015	.2323	.2551	1-782	.0264	68.60
LARK	397.5	30/ 7	.3850	.806	.623	20300	.435	.1007	.2306	.2533	1-773	.0277	60.35
PELICAN	477.0	18/ 1	.3954	.814	.518	11800	.441	.1004	.1957	.2148	1-844	.0264	86.45
FLICKER	477.0	24/ 7	.4232	.846	.615	17200	.432	.0992	.1943	.2134	1-889	.0284	73.25
HAWK	477.0	26/ 7	.4356	.858	.657	19500	.430	.0988	.1931	.2120	1-782	.0289	68.60
HEN	477.0	30/ 7	.4620	.883	.747	23800	.424	.0980	.1919	.2107	1-773	.0304	60.35
OSPREY	556.5	18/ 1	.4614	.879	.604	13700	.432	.0981	.1679	.1843	1-844	.0284	86.45
PARAKEET	556.5	24/ 7	.4938	.914	.717	19800	.423	.0969	.1669	.1832	1-889	.0306	73.25
DOVE	556.5	26/ 7	.5083	.927	.766	22600	.420	.0965	.1663	.1826	1-782	.0314	68.60
EAGLE	556.5	30/ 7	.5391	.953	.872	27800	.415	.0957	.1651	.1812	1-773	.0327	60.35
PEACOCK	605.0	24/ 7	.5368	.953	.780	21600	.418	.0957	.1536	.1685	1-889	.0319	73.25
SQUAB	605.0	26/ 7	.5526	.966	.833	24300	.415	.0953	.1529	.1679	1-782	.0327	68.60
TEAL	605.0	30/19	.5835	.994	.940	30000	.410	.0944	.1517	.1665	1-757	.0341	60.90
KINGBIRD	636.0	18/ 1	.5272	.940	.691	15700	.424	.0960	.1484	.1627	1-844	.1915	86.45
ROOK	636.0	24/ 7	.5643	.977	.819	22000	.415	.0950	.1461	.1603	1-889	.0327	73.25
GROSBEAK	636.0	26/ 7	.5809	.990	.875	25200	.412	.0946	.1454	.1596	1-782	.0335	68.60
EGRET	636.0	30/19	.6134	1.019	.988	31500	.406	.0937	.1447	.1589	1-757	.0352	60.90
FLAMINGO	666.6	24/ 7	.5914	1.000	.859	23700	.412	.0943	.1397	.1533	1-889	.0335	73.25
CROW	715.5	54/ 7	.6340	1.036	.921	26300	.407	.0932	.1304	.1430	1-838	.0349	73.25
STARLING	715.5	26/ 7	.6535	1.051	.985	28400	.405	.0948	.1294	.1420	1-537	.0355	68.60
REDWING	715.5	30/19	.6901	1.081	1.111	34600	.399	.0920	.1287	.1412	1-757	.0373	60.90
CUCKOO	795.0	24/ 7	.7035	1.092	1.024	27900	.402	.0915	.1193	.1308	1-889	.0366	73.20
DRAKE	795.0	26/ 7	.7261	1.108	1.094	31500	.399	.0912	.1172	.1284	1-537	.0373	68.60
MALLARD	795.0	30/19	.7668	1.140	1.235	38400	.393	.0904	.1159	.1272	1-757	.0392	60.90
COOT	795.0	36/ 1	.6416	1.040	.805	16500	.411	.0930	.1197	.1311	1-898	.0337	92.70
TERN	795.0	45/ 7	.6676	1.063	.896	22100	.406	.0925	.1188	.1302	1-955	.0352	83.70
CONDOR	795.0	54/ 7	.7053	1.093	1.024	28200	.400	.0916	.1174	.1286	1-838	.0370	73.25
CRANE	874.5	54/ 7	.7766	1.146	1.126	31400	.395	.0902	.1073	.1176	1-838	.0386	73.25
RUDDY	900.0	45/ 7	.7555	1.131	1.015	25400	.399	.0905	.1062	.1163	1-955	.0374	83.70
CANARY	900.0	54/ 7	.7985	1.162	1.159	31900	.393	.0898	.1041	.1140	1-838	.0392	73.25
RAIL	954.0	45/ 7	.8011	1.165	1.075	25900	.395	.0897	.0997	.1092	1-955	.0386	83.70
CARDINAL	954.0	54/ 7	.8464	1.196	1.229	33800	.390	.0890	.0988	.1082	1-838	.0402	73.25
ORTOLAN	1033.5	45/ 7	.8678	1.213	1.165	27700	.390	.0885	.0924	.1011	1-957	.0402	83.70
CURLEW	1033.5	54/ 7	.9169	1.246	1.331	36600	.385	.0877	.0914	.1000	1-838	.0402	73.25
BLUEJAY	1113.0	45/ 7	.9346	1.259	1.255	29800	.386	.0874	.0861	.0941	1-957	.0415	83.70
FINCH	1113.0	54/19	.9849	1.293	1.431	39100	.380	.0866	.0856	.0937	1-1009	.0436	73.70
BUNTING	1192.5	45/ 7	1.0010	1.302	1.344	32000	.382	.0864	.0809	.0884	1-957	.0429	83.70
GRACKLE	1192.5	54/19	1.0550	1.338	1.533	41900	.376	.0856	.0798	.0873	1-1009	.0451	73.70
BITTERN	1272.0	45/ 7	1.0680	1.345	1.434	34100	.378	.0855	.0762	.0832	1-957	.0444	83.70
PHEASANT	1272.0	54/19	1.1260	1.382	1.635	43600	.372	.0847	.0751	.0821	1-1009	.0466	73.70
DIPPER	1351.5	45/ 7	1.1350	1.386	1.522	36200	.374	.0846	.0721	.0786	1-957	.0459	83.70
MARTIN	1351.5	54/19	1.1960	1.424	1.737	46300	.368	.0838	.0710	.0775	1-1009	.0482	73.70
BOBOLINK	1431.0	45/ 7	1.2020	1.427	1.613	38300	.371	.0837	.0684	.0746	1-957	.0470	83.70
PLOVER	1431.0	54/19	1.2660	1.465	1.840	49100	.365	.0829	.0673	.0735	1-1009	.0494	73.70
NUTHATCH	1510.5	45/ 7	1.2680	1.466	1.702	40100	.367	.0829	.0649	.0707	1-957	.0486	83.70
PARROT	1510.5	54/19	1.3370	1.506	1.942	51700	.362	.0821	.0643	.0701	1-1009	.0506	73.70
LAPWING	1590.0	45/ 7	1.3350	1.502	1.792	42200	.364	.0822	.0623	.0678	1-957	.0498	83.70
FALCON	1590.0	54/19	1.4070	1.545	2.044	54500	.358	.0814	.0612	.0667	1-1009	.0523	73.70
CHUKAR	1780.0	84/19	1.5120	1.602	2.074	51000	.355	.0803	.0560	.0609	1-1020	.0536	81.30
BLUEBIRD	2156.0	84/19	1.8310	1.762	2.511	60300	.344	.0776	.0476	.0515	1-1020	.0586	81.20
KIWI	2167.0	72/ 7	1.7760	1.737	2.303	49800	.348	.0782	.0482	.0521	1-1053	.0568	89.20
THRASHER	2312.0	76/19	1.9140	1.802	2.526	57300	.342	.0767	.0446	.0482	1-1202	.0595	86.70
JOREE	2515.0	76/19	2.0830	1.880	2.749	61700	.337	.0755	.0418	.0450	1-1202	.0621	86.70